C. A. C. I.

Announces a New Course on

INTRODUCTION

to

SIMULATION

Using GPSS

Plus New

SIMSCRIPT I.5*

and

SIMOPTIMIZATION*

Course Dates

THE SIMSCRIPT I.5 COMPILER FOR IBM S/360 IS AVAILABLE

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COURSE DATES

INTRODUCTION TO SIMULATION USING GPSS

Intended for Managers
Corporate Planners
Operations Research Analysts
Management Scientists
Consultants
Military Officers
Government Officials
Project Leaders
and Others

#1 Los Angeles	Jan. 21-24, 1969
#2 Wash., D.C.	May 6-9, 1969
#3 Los Angeles	Sept. 9-12, 1969

SIMSCRIPT I.5

#28 Wash., D.C.,	Nov. 18-22, 1968
#29 Los Angeles	Jan. 27-31, 1969
#30 Wash., D.C.	April 21-25, 1969
#31 Los Angeles	July 21-25, 1969
#32 Wash., D.C.	Sept. 22-26, 1969

SIMOPTIMIZATION

#6 Wash., D.C.	Dec. 4-6, 1968
#7 Los Angeles	April 9-11, 1969
#8 Wash., D.C.	Aug. 6-8, 1969

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INTRODUCTION TO SIMULATION USING GPSS—Offered for the first time—a Four-Day Course on Simulation as an Aid to Management.

No. 1 Los Angeles.....January 21-24, 1969
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INTRODUCTION TO SIMULATION USING GPSS

The objective of this course is to send participants back to their organizations with a general understanding of simulation and a specific knowledge of simulation as it can be applied to their own company requirements.

This is a course in fundamental principles. It is intended for corporate planners, operations research analysts, management scientists, consultants in data processing, military officers, government officials, project leaders, and others who wish to improve their decision-making procedures by using simulation techniques. It is not a programming course, although the decision-maker needs to know and understand what the computer and programmer can do.

Presentations will be made on a management level by experts in the field of simulation. The instructors are familiar with a large variety of simulation models and applications, and are able to expound simulation from the standpoint both of the decision-maker's design and of implementation.

Technological jargon will be stripped away from the discussions to clarify fundamental principles of simulation. After the general explanation, participants will learn of specific models that parallel possible applications in their own work. GPSS (General Purpose System Simulator) will be used to illustrate the sample models because its flow chart structure is easily understood and learned. The models will be discussed in detail only insofar as they demonstrate principles relevant to the new and broader uses of simulation in corporations and other large organizations. Later discussion of models will focus on specific applications suggested by participants.

In order to make intelligent decisions about simulation techniques, managers need to know answers to such questions as:

- ☐ What is simulation and how does it work?
- ☐ What are the advantages and disadvantages of simulation?
- ☐ How does simulation compare with analytical techniques such as linear or dynamic programming, queueing theory, etc.?
- ☐ What areas of analysis can simulation be applied to?
- ☐ What is the difference between the Model and the Program?
- ☐ Where does the decision-maker leave off and the computer programmer begin? What are their areas of joint responsibility?
- ☐ What are the significant features of the available simulation programming languages? What are their relative advantages?
- ☐ What factors must be considered in the design of a successful simulation experiment?
- ☐ What is the role of data collection in simulation analysis?
- ☐ What kinds of answers are provided by simulations? How do decision-makers interpret the output? What are the pitfalls in interpretation?
- ☐ What are some concrete examples of the modeling process? What unique principles do the examples illustrate?
- ☐ How can simulation techniques be applied to my areas of interest?

Participants will see how, in simulation analysis, the computer traces out the consequences of a proposed system, course of action, or management decision. Compared with other forms of analysis of the specific problems, it will be demonstrated that simulation is more realistic, more easily understood, and more conclusive. For these reasons, conclusions produced by simulation win readier acceptance at all management levels.

PREREQUISITES There are no specific prerequisites.

FEE $250.

TEXTS In addition to a GPSS Manual, all classroom materials such as forms, problems, journal articles, etc., will be provided without extra charge.

INSTRUCTORS Yen Chao, Michael Jakes, and Ernel Luther.

AGENDA

Tuesday	FUNDAMENTAL CONCEPTS What is Simulation? Advantages and Disadvantages of Simulation Analytical Methods vs. Simulation Principles of the modeling process
Wednesday	The GPSS LANGUAGE The World View of GPSS The Block Diagram Approach to Describing the Modeled System
Thursday	APPLICATIONS Survey of successful applications: Waiting Line Model; Telephone Reservation Model; Computer Service Center Model
Friday	DISCUSSION AND SUMMARY Survey of Simulation Languages The Approach to Typical Realistic Problems and Problems Suggested by Participants

LOCATIONS

All courses in the Los Angeles area are held at the Royal Inn, 1819 Ocean Avenue, Santa Monica, California 90405, Phone (213) 451-8711.

All courses in the Washington, D.C., area are held at the Marriott Key Bridge Motor Hotel, U.S. #29 and 211, Washington, D.C., 20007, Phone (703) 524-6400.

Offered for the First Time
SIMULATION USING GPSS

Models.

No. 6 Washington, D.C.....December 4-6, 1968
No. 7 Los Angeles .....April 9-11, 1969
No. 8 Washington, D.C. .....August 6-8, 1969

SimOptimization is a Trademark and Service Mark of Consolidated Analysis Centers Inc.*

SIMOPTIMIZATION*

SimOptimization incorporates the automatic procedures of analytical optimization techniques within the realism of digital simulation analysis to obtain the best features of both worlds.

Analytical optimization techniques are often unsatisfactory because they do not permit sufficient detail in characterizing the system being analyzed. Simulation models, on the other hand, allow as much detail as desired but, until recently, have always had a serious drawback in that even "good" solutions were obtained only through a clumsy and costly process of trial-and-error. Faced with a vast or infinite parameter space, the analyst is often bewildered as to what cases to run in search of a better solution and slowly buries himself under a mountain of expensive computer runs.

SimOptimization was developed by C.A.C.I. under the sponsorship of the Office of Naval Research.

SimOptimization (SimOp for short) provides automatic optimum-seeking procedures for simulation analyses to permit the efficient location of improved (even local optimum) solutions by means of successive runs. The solutions located by SimOp are probably close to the optimum, however, this cannot be shown rigorously. At the least, SimOp provides a good solution to a *realistic model* which is preferable to an optimum solution to an *overly simplified model.*

Actual experience shows the efficiency of SimOptimization to be far greater than a human analyst could hope to achieve. By eliminating the need for trial-and-error search, SimOp significantly enhances the usefulness of simulation analysis.

THREE STAGE APPROACH SimOptimization currently consists of a series of three techniques designed to be applied sequentially. The techniques are not program packages but concepts that must be tailored to the individual requirements of each model.

Decentralized Gradient Approach. The first technique is named the Decentralized Gradient Approach (DGA). The objective of DGA is to quickly set the free policy parameters of the simulation close to the optimum. Using the internal details of the simulation and a decentralization of the system, DGA is able to formulate hypotheses about improved solutions which are then resimulated automatically. The decentralization process permits the simultaneous adjustment of *all free parameters* from one simulation to the next.

Empirical results show that DGA is capable of making large improvements with a very few simulation runs. In achieving this very efficient operation, certain second-order interactions are ignored by DGA; this sometimes results in missing nearby preferable solutions. If it is desired to search for improvements beyond the final DGA solution, more sensitive procedures are available.

Linear Response Surface Approach. The Linear Response Surface (LRS) procedure consists of conducting a simple search in the vicinity of the best known solution (the last DGA solution or the best LRS solution thus far). One parameter at a time is increased or decreased by one unit and the simulation is rerun. The cost of LRS is relatively high due to the number of simulation runs necessary, and improvements over the DGA solution are usually relatively small. For LRS costs.

Quadratic Response Surface Approach. The third procedure is the Quadratic Response Surface (QRS) approach which approximates the system criterion function by a quadratic, from which the optimum solution is calculated. The quadratic solution is then tested by simulation if it differs from the best known solution.

APPLICABILITY OF SIMOPTIMIZATION SimOp is applicable to a variety of simulation models for which one or more types of policy parameters are to be adjusted to yield an optimum system design or tactic. SimOp has been applied to a number of task-resource models such as job shops and communication networks. Although development and refinement continue, the procedures can now be applied to most modeling activities.

THE COURSE The SimOptimization course is designed to give the student a basic understanding of the techniques so that he may apply them to his own problems. Complete details of the three techniques and how they should be applied will be discussed. Applications made to date will be presented together with the results and their analyses.

PREREQUISITES The course is designed for the analyst, model designer, or programmer with an understanding of the goals and usage of simulation modeling. No specific programming knowledge is required.

FEE

TEXTS (Published by C.A.C.I.) "SimOptimization Research, Phase I," by H. Karr, E. Luther, H. Markowitz, and E. Russell, CACI 65-P2.0-1.

"SimOptimization Research, Phase II," by E. Luther and H. Markowitz, CACI 66-P2.0-1.

INSTRUCTORS Ernel Luther, and Noel Wright.

AGENDA

Wednesday	Introduction: The Three SimOptimization Techniques—their purpose and objectives Case History: Job Shop The model and empirical results Case History: Communication Network The model and empirical results Class Participation Exercise I
Thursday	Comments on General Search Theory Additional Case Studies Analysis of Convergence and Efficiency Theory of Decentralization in Economics and Optimization Class Participation Exercise II
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If you need SIMOPTIMIZATION applied to your simulation work, why not let C.A.C.I.'s experts do it for you?

SIMOPTIMIZATION* TECHNIQUES—A three-day Course on Automatic Optimum-Seeking Procedures for Simulation Models.

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SIMSCRIPT I.5* Training Courses For Programmers—Operations Researchers—Management Scientists—Software Specialists—Simulation Project Managers.

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No. 32 Washington, D.C..............September 22-26, 1969

SIMSCRIPT I.5*

SIMSCRIPT AND SIMULATION Computer simulation is being used more and more as an aid to important decision making. Simulation analysis pretests proposals under alternate contingencies in advance of implementation. To a certain extent, it provides hindsight in advance.

Digital simulation became practical largely owing to the development of a variety of simulation programming techniques, including the original SIMSCRIPT. Today SIMSCRIPT I.5 is the simulation language that computer manufacturers have adopted as the standard for most large computers.

The original SIMSCRIPT achieved a four- or five-to-one reduction in programming time as compared with FORTRAN (30 or 40 to one as compared with machine language). SIMSCRIPT I.5 reduces programming time even more, reduces compilation and execution time, provides interchangeability from one computer to another, and offers still other advantages described below.

SIMSCRIPT I.5 provides the analyst with a "world view" or method of modeling, and provides the programmer, analyst, and manager with a common language for describing the modeled system. SIMSCRIPT I.5 also provides flexibility for rapid modifications in the structure of the simulation program.

Through direct compilation rather than translation into FORTRAN, the new SIMSCRIPT I.5 eliminates the running of special procedures and more than doubles compilation speed.

SIMSCRIPT I.5 PROGRAMS Digital simulations generally consist of a numerical description of the "status" of the simulated system. This status description is modified at various points in simulated time which may be called "events." SIMSCRIPT I.5 simulations consist primarily of a collection of "event routines" written by the user describing how different kinds of events in a particular simulated world affect current status and cause future events. Status is described in terms of various "entities," "attributes," and "sets" which are specified by the user on a standard definition form.

AUTOMATICALLY GENERATED ROUTINES A number of subprograms required for simulation are generated by SIMSCRIPT I.5 either automatically or with a minimum of user specification:

☐ A tailor-made timing routine is automatically provided to keep track of simulated time and to call on user-supplied "event routines" as simulated events occur.

☐ Filing routines are generated for inserting and removing entities from sets according to the particular set disciplines specified by the user.

☐ Routines are provided for the setting of dimensions and the input of initial data at the start of each run, for the assignment and return of space during the course of a run, and for the packing and unpacking of data from fractional words of core.

☐ Various procedures are available for generating random variables.

of SIMSCRIPT I.5. On the layout form, the user specifies text—titles, column headings, etc.—merely by writing the text in the print position where he wishes it to appear. Numerical fields are indicated by inserting asterisks in the appropriate print positions. Thus, the general appearance of the output can be visualized directly from the layout form. This completely eliminates lengthy and troublesome formatting and character count with its accompanying errors.

The variables or functions to be printed in the respective numerical fields are specified merely by writing their source language names directly onto the layout form. Heading and spacing controls, and column and row repetition are also similarly specified directly on the form.

All further coding required to obtain the desired output routine is done automatically by SIMSCRIPT I.5. Because of the ease in writing and modifying reports, programmers typically produce reports that are superior in content and appearance, and are easier to read and comprehend.

UNIQUE COMMANDS The SIMSCRIPT I.5 language provides commands particularly suitable for simulation event routines.

Single commands such as CAUSE, CANCEL, CREATE, DESTROY, FILE, and REMOVE accomplish such actions as causing and cancelling simulated events, creating and destroying entities, inserting and removing entities from sets.

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Repeated execution of individual statements or groups of statements may be selectively controlled by combinations of FOR, WITH, AND, or OR phrases.

In addition to its unique features, the language contains a complement of IF, GO TO, DO TO, arithmetic, and input-output commands. Subscripts may be subscripted to any depth. Assembly-language statements can be inserted anywhere in SIMSCRIPT I.5 programs to accomplish unconventional operations.

SIMSCRIPT I.5 APPLICABILITY SIMSCRIPT I.5 is applicable to virtually any kind of simulation problem, and may be used for simulating either discrete or continuous processes. It has been used effectively in building an extremely wide variety of simulation models, including models of: communication networks—steel mills—ground and amphibious warfare—missile launchings—pipelines—cancer growth—time-shared computers—supply systems—job shops and flow shops—computer centers—maintenance systems—and many others.

SIMSCRIPT I.5 AS A GENERAL LANGUAGE Although SIMSCRIPT I.5 was developed for simulation problems, it is a general programming system, and may be used for non-simulation programs as well. Its Report Generator, dimension-free memory, ease of program modification, generalized list processing capabilities, etc., are particularly desirable for: optimization calculations—heuristic programming—information storage and retrieval—statistical analysis—data reduction and display—and business data processing.

THE COURSE The course is designed to give the student a sound working knowledge of SIMSCRIPT I.5 programming. All details of the use of the system will be presented in lectures and in supervised exercise sessions.

PREREQUISITES The course is designed for both programmers and for non-programmer analysts who have a familiarity with at least one programming language such as FORTRAN or MAP.

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REPORT GENERATOR The Report Generator has been widely acclaimed for both simulation and nonsimulation uses

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the text, classroom materials such as forms, problems, sample compilations, etc., are provided.

INSTRUCTORS Ernel Luther, Ronald Steorts, Jay Casey, and William McQuiggan.

FEE $300.

AGENDA

Monday	Simulation—history and use. Basic Concepts of SIMSCRIPT I.5. Status—Entities, Attributes, Sets. Events—Exogenous, Endogenous. The SIMSCRIPT I.5 Definition Form. Set Description. Storage and data packing designation for Entities and their Attributes
Tuesday	SIMSCRIPT I.5 Commands—CREATE, DESTROY, CAUSE, CANCEL, FILE, REMOVE, LET, READ, DO TO, FOR, WITH, AND, OR, IF, GO TO, FIND, COMPUTE, ACCUMULATE, etc.
Wednesday	The SIMSCRIPT I.5 Report Generator Form, Content, Control Compile and Execute Procedures Compile Deck, Initialization Form, Data Deck Practice Session I Problem Descriptions
Thursday	Simulation of large systems Nonsimulation Programs in SIMSCRIPT I.5 Modification of SIMSCRIPT I.5 Programs Practice Session II
Friday	Some tricks of the trade derived from the authors' and others' experience in applying SIMSCRIPT I.5 Review and Discussion

PRIVATE COURSES

If you have a number of staff members to be trained, it may be more convenient and economical to arrange for a private course. The same training courses can be given at your facility for personnel from your own organization and possibly other organizations from your area. The fees for private courses are as follows:

INTRODUCTION TO SIMULATION USING GPSS: $2,500 for up to 20 students plus travel* and living expenses for two instructors. For more than 20 students, the fee is $125 per student.

SIMOPTIMIZATION: $2,000 for up to 20 students plus travel* and living expenses for two instructors. For more than 20 students, the fee is $100 per student.

SIMSCRIPT I.5: $3,000 for up to 20 students plus travel* and living expenses for two instructors. For more than 20 students, the fee is $150 per student.

**From nearest major C.A.C.I. office.*

SPECIAL ARRANGEMENTS FOR COURSES AND COMPILERS ARE AVAILABLE FOR UNIVERSITIES.

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COURSE ENROLLMENT

Enter my enrollment in the courses checked below:

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AGENDA

Monday	Simulation—history and use. Basic Concepts of SIMSCRIPT I.5. Status—Entities, Attributes, Sets. Events—Exogenous, Endogenous. The SIMSCRIPT I.5 Definition Form. Set Description. Storage and data packing designation for Entities and their Attributes
Tuesday	SIMSCRIPT I.5 Commands—CREATE, DESTROY, CAUSE, CANCEL, FILE, REMOVE, LET, READ, DO TO, FOR, WITH, AND, OR, IF, GO TO, FIND, COMPUTE, ACCUMULATE, etc.
Wednesday	The SIMSCRIPT I.5 Report Generator Form, Content, Control Compile and Execute Procedures Compile Deck, Initialization Form, Data Deck Practice Session I Problem Descriptions
Thursday	Simulation of large systems Nonsimulation Programs in SIMSCRIPT I.5 Modification of SIMSCRIPT I.5 Programs Practice Session II
Friday	Some tricks of the trade derived from the authors' and others' experience in applying SIMSCRIPT I.5 Review and Discussion

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